STANDARD AND DECONSTRUCTION

A.APR.1	**Understand that polynomials form a system analogous to the integers, namely, they are closed under the operations of addition, subtraction, and multiplication; add, subtract, and multiply polynomials.**
DESCRIPTION	A.APR.1 Understand the definition of a polynomial. A.APR.1 Understand the concepts of combining like terms and closure. A.APR.1 Add, subtract, and multiply polynomials and understand how closure applies under these operations. Focus on polynomial expressions that simplify to forms that are linear or quadratic in a positive integer power of x. In the traditional pathway, linear and quadratic polynomial expressions are the expectation in Algebra I and beyond quadratic polynomial expressions is the expectation for Algebra II. In the international pathway, CCSS Mathematics II places emphasis on polynomials that simplify to quadratics and CCSS Mathematics III extends beyond quadratics.
ESSENTIAL QUESTION(S)	What strategies can be used to perform arithmetic operations on polynomials?
MATHEMATICAL PRACTICE(S)	HS.MP.8. Look for regularity in repeated reasoning.
DOK Range Target for Instruction & Assessment	☒ 1 ☐ 2 ☐ 3 ☐ 4

Learning Expectations	**Know: Concepts/Skills**	**Think**	**Do**
Assessment Types	Tasks assessing concepts, skills, and procedures.	Tasks assessing expressing mathematical reasoning.	Tasks assessing modeling/applications.
Students should be able to:	Define closure. Identify that the sum, difference, or product of two polynomials will always be a polynomial, which means that polynomials are closed under the operations of addition, subtraction, and multiplication. Apply arithmetic operations of addition, subtraction, and multiplication to polynomials.		

EXPLANATIONS AND EXAMPLES

Students should understand that polynomials, like integers, are "closed" when it comes to addition, subtraction, and multiplication. Basically, this just means they're kind of cliquey as far as these operations are concerned.

An integer plus an integer is an integer, an integer minus an integer is an integer, and an integer times an integer is an integer. Similarly, a polynomial plus a polynomial is a polynomial, a polynomial minus a polynomial is a polynomial, and a polynomial times a polynomial is a polynomial. If that isn't cliquey, we don't know what is.

Students should know that a **polynomial** is any expression that is a combination of more than one term via addition or subtraction. Each individual term is called a **monomial**. Monomials can be constant (like single numbers) or include variables to different degrees (like x6). As long as it's in one lump with no plus or minus signs, it's a monomial.

Some examples of polynomials include:

- $x + 4$
- $x^2 + 2$
- $2x^2 - 3x + 5$
- $x^6 + 4x^5 - 3x^2 + x$

EXPLANATIONS AND EXAMPLES (continued)

Polynomials are really nice to work with because they're continuous and defined for all values. In other words, we can replace x with any real number, and we'll get a real number as our result. Just don't rub it in Pinocchio's ever-growing nose. He's always wanted to be real.

For example, take the polynomial $x^3 + 2^x - 5$. Input any value of x, like 6, and we'll get a real number, like $(6)^3 + 2(6) - 5 = 223$. Students should know that adding, subtracting, and multiplying two or more polynomials together will give them a polynomial. A different polynomial, but still a polynomial.

However, polynomials are not closed (so they're…open?) under division because sometimes the quotient won't be another polynomial. Take this quotient of polynomials, for example:

$$\frac{x^3 + 4x^2 + 2x - 5}{x^2 + 3x + 1}$$

This is a rational expression, not a polynomial. Somehow, polynomials seem a lot more rational.

Definitions are crucial for students to understand before learning how to actually perform operations on polynomials.

Students should know that when adding and subtracting polynomials, we can only combine like terms with like terms. Constants can only be added to constants, x terms can only be added to x terms, x^2 terms can only be added to x^2 terms, and so on.

If addition and subtraction are like OCD, meticulously pairing terms that go together, then multiplication is like ADHD, combining any and all terms together in one big dog pile regardless of what they are.

Students should know that multiplying a polynomial by a monomial means distribution, and that multiplying two polynomials together means a lot of distribution. More specifically, we have to make sure to multiply every term in one polynomial by every term in the other polynomial.

For instance, students performing the operation $(x + 2) \times (x^3 + x - 7)$ should know to first distribute the x to get $x^4 + x^2 - 7x$, and then the 2 to get $2x^3 + 2x - 14$, and then to add the two together so that the final answer is $x^4 + 2x^3 + x^2 - 5x - 14$.

When two binomials are multiplied together, like $(x + 1)(x + 3)$, most students prefer to remember the acronym FOIL, which stands for multiplying the First, Outer, Inner, and Last numbers together.

The best way to get students to feel comfortable is to have them practice, but have them stick to operations like addition, subtraction, and multiplication at first. They'll get to more complicated operations such as lobotomies and appendectomies later…like, after med school..

(Source: www.shmoop.com)